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THOMAS PRECESSION AND EXTENDED
STRUCTURES

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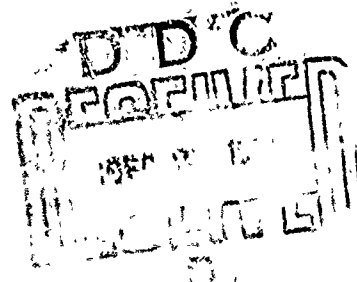
13. ABSTRACT

It is shown that Weinstein and Whitmire in extending the Thomas precession to an extended rotating disk have made implicit assumptions about integrability, common disk times, and the disk proper frame which have not been justified.

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Thomas Precession and Extended Structures.

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(ricevuto il 22 Maggio 1972)

CAVALLERI⁽¹⁾ has commented on a recent series of letters⁽²⁻⁹⁾ which have appeared in NATURE. These letters have dealt with Ehrenfest's paradox of the relativistic rotating disk. The letters of WEINSTEIN⁽⁷⁾ and WHITMIRE⁽⁹⁾ have brought the Thomas precession into the discussion. CAVALLERI has discussed their ideas in terms of the relativistic mechanics of elastic media. I should like to show that both WEINSTEIN and WHITMIRE, in applying the Thomas precession to the extended disk, have made certain implicit assumptions which should be examined more fully.

Now the Thomas precession is derived by considering the group properties of successive Lorentz transformations. Two successive Lorentz transformations which are not co-parallel are physically equivalent to a single Lorentz transformation plus a rotation. This is discussed quite fully by FURRY⁽¹⁰⁾, MOLLER⁽¹¹⁾ and JACKSON⁽¹²⁾. In essence a point particle travels in a torque-free, circular orbit and the relation between the inertial frame in which the particle is instantaneously at rest and the inertial frame of an external observer is examined. In all discussions of the Thomas precession the extension of the particle concerned is completely neglected.

Both WEINSTEIN and WHITMIRE have extrapolated the precession to an extended disk. WEINSTEIN considers the precession for an infinitesimal element of the disk and then integrates over the element. To carry out this integration requires very specific statements about time at every disk position. Each point of the disk is instantaneously at rest in a frame which moves with velocity $v = \Omega r$ with respect to the laboratory in which the disk rotates. Here Ω is the disk angular velocity and r the radial distance from the center. Therefore we require an infinity of nonparallel inertial frames, each moving with a different velocity v , with respect to the laboratory frame.

⁽¹⁾ G. CAVALLERI: *Let. Nuovo Cimento*, **3**, 608 (1972).

⁽²⁾ H. A. ATWATER: *Nature*, **228**, 272 (1970).

⁽³⁾ H. A. ATWATER: *Nature*, **230**, 197 (1971).

⁽⁴⁾ M. SUZUKI: *Nature*, **230**, 13 (1971).

⁽⁵⁾ G. E. MARSH: *Nature*, **230**, 197 (1971).

⁽⁶⁾ T. W. NOONAN: *Nature*, **230**, 197 (1971).

⁽⁷⁾ D. H. WEINSTEIN: *Nature*, **232**, 548 (1971).

⁽⁸⁾ W. H. MCCREA: *Nature*, **234**, 390 (1971).

⁽⁹⁾ D. P. WHITMIRE: *Nature*, **235**, 175 (1972).

⁽¹⁰⁾ W. H. FURRY: *Amer. Journ. Phys.*, **23**, 517 (1955).

⁽¹¹⁾ C. MOLLER: *Theory of Relativity*, (Oxford, 1952), p. 118.

⁽¹²⁾ J. D. JACKSON: *Classical Electrodynamics*, (New York, 1967), p. 364.

Each frame naturally has its own time and each infinitesimal element of the disk has its own Thomas precessional velocity as seen by the laboratory observer. WEINSTEIN has not demonstrated the integrability of his eq. (1), though it may indeed be valid.

Whitmire has shown that extending the Thomas precession to macroscopic objects can result in a paradox in which a macroscopic disk element is forced to move in opposite directions simultaneously. Whitmire's paradox might be looked at as arising from our simply not knowing how to extend the Thomas precession to the entire disk or even to two circular regions of the same size at the same radial position. In any discussion we must remember that each point of the disk is instantaneously at rest in a different inertial frame. Moreover, the proper frame of the disk is noninertial. In addition, it should be noted that the precession is a kinematic not a dynamic effect, a point discussed in a recent paper⁽¹²⁾ relating the Thomas precession to the relativistic right-angled lever. When applied to point particles, the Thomas precession is observed in the inertial laboratory frame but not in the particle's proper frame. This suggests a question as to the frame in which the "Thomas shear stresses" (as WHITMIRE has called them) are to be observed. Is it the inertial laboratory frame or the disk proper frame or both? Moreover, the kinematic nature of the precession would make the physical origin of such shear stresses (if they exist) most mysterious. As the paper of ref. (12) indicates, the Thomas precession is completely torque-free.

We do not know whether these Thomas shear stresses can be set up in a rotating disk. At present this question can be answered only by appeal to experiment. Until now the Thomas precession has been justified for microscopic bodies only, namely elementary particles such as the electron, and is purely kinematic in nature. The extrapolation of this precession to extended structures without a discussion of common disk time or the disk proper frame is, I feel, most questionable.

(12) R. G. NEWBURG: *Amer. Journ. Phys.*, **38**, 1158 (1970).

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